A proposal to Brookhaven National Laboratory for

STAR Trigger Capital Equipment: QT Electronics

We propose to fabricate and install new QT boards for the FPDE, BBC, ZDC, PXZ, VPD[1] and other miscellaneous detectors under development at the STAR experiment at Brookhaven National Laboratory's (BNL) Relativistic Heavy Ion Collider (RHIC). These detectors currently use a combination of digitizer boards (CDBs) and Data-Storage-and-Manipulation boards (DSMs) designed 15 years ago which are no longer supportable. The proposed QT board replacement will provide better sensitivity (12-bit vs 8- bit ADCs), superior noise immunity, and more powerful logic engines required for sophisticated trigger decisions. Each QT board replaces typically 2 CBDs and 2 DSMs in the trigger system. Producing the QT boards we propose here will free up at least 20 DSM boards for use elsewhere in the Level0 trigger system. This proposal covers the cost to produce the QT boards, to design and fabricate the replacement Time-to-Amplitude-Converter (TAC) boards, and to replace the P3 backplane in 3 of the existing VME crates required for installation at STAR.

The QT electronics design was driven by a set of requirements imposed by our desire to reconstruct mesons and to determine the energy of isolated direct photons in the Forward Meson Spectrometer (FMS). For details please see (http://hena.lbl.gov/FMS/electronics-reqs-final.pdf). There are 48 QT boards now in use at STAR. Beam energies at RHIC set the energy scale for the electronics. The upper limit is set by quarks carrying a large fraction of the initial nucleon momentum (x_F), up to 200 GeV. The lower limit is set by the need to ensure photon isolation by detecting even the lowest energy partners of electromagnetic decays, down to 0.25 GeV. The accuracy is set by requiring small uncertainty in reconstructed particle masses, typically 0.05 GeV per daughter. This leads to a requirement for a 12-bit amplitude-to-digital-converter (ADC). Beam-related backgrounds place an additional requirement that we measure the signal arrival time at each detector cell to an accuracy of ~5ns in the QT board.

To meet the requirements we designed and fabricated the 32-channel QT motherboard (QT32), and the 8 channel digitizing daughter boards (QT8). The QT32 board handles all VME transactions and control functions, gathering the pulse amplitudes (ADC) and the hit times (TDC) from each of its 4 QT8 daughter boards. The QT32 board controls data flow to both the STAR Level0 trigger system and to the Level2 data acquisition system. The ADC is a 70MHz 8-channel chip that feeds 12 bits of ADC into a Field-Programmable-Gate-Array (FPGA). The time-to-digital amplitude converter (TDC) is accomplished with a simple 200 MHz shift register: the leading edge of a discriminator (DISC) on the input is recorded in coincidence with the shift clock to give a 5ns sensitivity TDC.

The Forward Pion Detector East (FPDE) consists of two sets of 49 channels of PbGl plus two sets of 7 pre-shower PMTs using CDBs and DSMs. We propose to instrument this

[1] acronyms are defined below

using 4 QT boards, 2 each for the North and South modules including the pre-showers. This detector also has coverage on the N and S arrays of two sets of 96 channels of shower max detector currently using CAMAC electronics and 16 anode MAPMTs. We propose to replace the CAMAC system with 6 QT boards.

The Beam-Beam-Counters (BBC) consist of two sets of 16 small-tile PMTs and two sets of 8 large-tile PMTs. Each PMT feeds both an ADC and a TAC+ADC channel for a total digitizer channel count of 96. We propose to replace the current CDB+DSM system with 4 QT32 boards. The current digitizer discriminator output that feeds the TAC boards is in ECL format, while the QT discriminator output is in PECL format[2]. Thus, to preserve our timing capabilities we need to design and fabricate a set of TAC boards accommodating PECL inputs. This is a straightforward modification to our existing TAC board design.

The Zero-Degree-Calorimeters (ZDC) system consists of 6 PMTs which form 16 channels of ADC and TAC. The current channel count of 16 represents an inconvenient constraint on this system. We propose to replace this with 1 QT board. The ZDC Pixel detector (PXZ) system consists of 16 channels of ADC. We propose to replace this with 1 QT board.

The MIX crate currently holds electronics for the Muon Tracking Detector (MTD), the Vertex Position Detector (VPD), the Time-of-Flight (TOF), and the pp2pp detectors. The reason for the name MIX is that these are disparate detectors under development. Some have analog inputs and some have digital. We use this crate to test ideas as well as for necessary trigger input. The current VPD uses four CDB + DSM boards. Again this system has both ADC and TAC channels. We propose to replace this with 4 QT boards to allow us to use dual discriminators on each channel in an attempt to improve the vertex resolution. PP2PP uses standard PMT anode inputs, but would profit from having the TDC capabilities of the QT for background hit discrimination. The MTD and TOF use digital input, and both are expected to grow and migrate to their own crates.

STAR standard VME crates use a custom P3 backplane for communication. In developing the QT system, we found that the cost for these backplanes has risen astronomically because the original company is no longer in business. Thus we opted to design using a standard P2 backplane in the P3 location, even though it has 64 fewer pins. Since we already have 2 VME crates for each of FPDE, BBC+ZDC+PXZ, and MIX, we do not need to purchase new crates. Instead, we will replace the existing P3 in four of the crates with standard P2 backplanes, with the labor for this done at BNL.

The Board counts are reflected in Table 1 below. Total costs are reflected in Table 2 below. The deliverables of this proposal consist of:

1. 24 QT32 boards

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[2] ECL drivers have become much more expensive than PECL drivers, and the channel count on the FMS drove this decision in the QT design.

2. 96 QT8 boards
3. software for control and operation
4. 10 TAC boards
5. 3 VME backplanes

Detector	CDBs	Layer0 DSMs	TACs	QTs
FPDE	7	7	0	10
BBC	6	6	3	4
ZDC	1	1	1	1
PXZ	1	1	0	1
VPD	4	4	4	4
MTD	2	2	0	1
PP2PP	2	2	0	1
Spares			2	2
Totals	23	23	10	24

Item	Cost per unit	Units	Total
QT 32 boards	$2200	24	$52.8k
QT8 boards	$700	96	$67.2k
TAC boards	$2500	10	$25k
P2 backplanes	$1000	3	$3k
Labor			$15k
Total			$163k